Approximately 50 pounds of a virgin silver impregnated carbon, produced by Degussa for use in the fumigation unit, was obtained to adequately supply initial development needs for 1993.

Several samples of silver–impregnated carbon (Ag/C) supplied by Lurgie (material used in the July 4 and September 4 studies) and several water samples were analyzed. The analyses were designed to evaluate the Toxicity Characteristic of virgin Ag/C, spent Ag/C, and measure the silver, orthophosphate, and total phosphorus concentration present in the water used to wash a bed of spent Ag/C.

The virgin Ag/C would be considered non–hazardous waste as determined by the TCLP methodology of extraction and silver analysis, and assuming no other regulated components are present. This also makes the reasonable assumption that the material is not reactive and not ignitable.

The spent Ag/C without a regeneration step would be considered a hazardous waste due to the high concentration of silver (19–51 ppm) present in the leachate, as determined via the TCLP protocol.

A spent sample of Ag/C was washed with tap water to simulate a regeneration step. The aqueous filtrate (pH = 1.5) was analyzed and found to contain 0.05 ppm silver. Spent Ag/C after tap water regeneration may not be a hazardous waste and should be examined via the TCLP protocol. The tap water regenerant would be considered a hazardous waste due to the low pH of this solution (Corrosivity Characteristic). The lack of water soluble silver may be due to the formation of silver chloride resulting from chloride in the tap water.

A sample of spent Ag/C was washed with deionized water (chloride content < 1 ppm) and the filtrate was analyzed for silver. The silver concentration was 35 ppm which supports the conclusion that the chloride in the tap water reacts with the silver to form insoluble silver chloride.

The feasibility of using aqueous oxidants to destroy phosphine was investigated. A stream (60 ml/min) of 300 ppm of phosphine in nitrogen was passed through an aqueous solution (0.01 M) of silver nitrate, copper sulfate pentahydrate, hydrogen peroxide, sodium hypochloride, sodium hydroxide, potassium persulfate, or potassium persulfate containing a catalytic amount of silver nitrate. Phosphine evolution from the reaction vessel was monitored as a function of time. The silver nitrate solution was the most efficient, followed by the potassium persulfate/silver nitrate combination. The remainder of the systems were significantly less efficient.

The capabilities of several commercial portable phosphine monitors have been demonstrated. Additional information and price quotes were requested.

Plans: To evaluate other aqueous oxidant systems. Investigate the synthesis of new supported oxidation catalysts and evaluate their effectiveness. To develop supported oxidation catalysis utilizing the expertise of one or more external companies specializing in catalytic chemistry.

Contributors: Product Research Division, Analytical Research Division, and Environmental Engineering

IV. **Objective:** To evaluate methods to destroy/convert nicotine into a non–toxic material which offers convenient disposal properties.

Results: UV photolysis (450 watt Hanovia broad wavelength UV light) of an aqueous nicotine solution (2428 ppm, pH = 9.95) resulted in the reduction of nicotine to undetectable levels in 16 hours. Another solution of nicotine acidified to pH = 3.5–4 was irradiated in a similar fashion to the non–acidified case. Under the acidified conditions, the nicotine was destroyed in 7 hours (approximately twice as fast as the non–acidified solution).

Plans: Evaluate UV and UV/ozone photolysis using actual aqueous process stream samples.

Contributors: Product Research Division

V. **Objective:** Support the R&D and Engineering 5–Year Plans addressing air, water, and solid waste issues.

A. **Strategy:** Provide analytical expertise related to sampling protocols and analytical schemes for qualitative and quantitative descriptions of air, water, and solid waste effluents.

1. **Results and Conclusions:** Nicotine was determined by HPLC for the samples taken during the October – November effluent evaluation tests at the Park 500 Facility. The analytical data included the appropriate information that is necessary for calculating the quality assurance aspects of the series and were sent to personnel at ERM for inclusion in their final report.

   ARD participated in the effluent evaluation tests for the Hauni steam tunnel at the Semiworks (December 1992). IEA, a consulting environmental analysis company, sampled the stacks to provide a total volatile organic (VOC) component value using the EPA Method 25A. ARD's samples of the effluent were taken by mini–impingers and analyzed to provide water data to IEA so they could correct their volumetric flow values. These samples were also analyzed by ARD for PG, glycerine, and nicotine. Purge and Trap techniques were applied in an effort to distinguish differences, if any, in volatile organic compounds released during steam tunnel on and off operating protocols. No qualitative differences were noted. Total volumetric flow data from IEA will be used along with amounts collected to compare the organic profiles for any quantitative differences.

   A second steam tunnel test was made during the first part of February. These samples are now being analyzed.

2. **Plans:** Continue support operations.

3. **Contributors:** Analytical Research Division

B. **Strategy:** To support Engineering by providing environmental analyses.

1. **Results and Conclusions:** Analyses of water samples were conducted. These analyses involved samples from experiments in charcoal filtration and scrubber

testing at Park 500. Coordination, data validation, and reporting of results are ongoing.

2. **Plans:** Continue support of the Environmental Program as required.

3. **Contributors:** Analytical Research Division

C. **Strategy:** Follow the TCLP protocol, collect, analyze, and scrutinize the data generated within PM and at the various contract laboratories, and transmit the data to the necessary personnel.

1. **Results and Conclusions:** The Environmental Protection Agency (EPA) has amended its hazardous waste regulation for the evaluation of a solid waste based on the Toxicity Characteristic Leaching Procedure. The new procedure, effective November 24, 1992, eliminates the spike recovery corrections previously required from the TCLP analysis. Appropriate quality assurance testing, including matrix spike recoveries, must still be conducted. The amended regulation should result in less material being classified as hazardous waste and save a significant amount in disposal costs.

2. **Plans:** Monitor contract labs to ensure compliance with this new regulation.

3. **Contributors:** Product Research Division

ANALYTICAL METHODS APPLICATION

Summary: Significant progress has been made on projects involving moisture, blend composition, and other ingredients. In the evaluation of the reference method for calibration of on–line moisture monitors, a new algorithm has been developed which appears to eliminate the "burley effect". In addition, the extraction time for the GC water reference method has been decreased from four–hours to less than five minutes using microwave treatment of the methanol/tobacco mixture. Comprehensive evaluations of the new algorithm and the extraction procedure are planned. In support of New Primary Technology, four and eight component models have been developed for single rod blend analysis (DBC blends only) using a combination of FTmidIR/NIR and X–ray fluorescence techniques. Prediction errors for individual components range from 3–10% absolute. These models have been used in the analysis of Marlboro cigarettes. Some additional work is in progress on fine–tuning these models; plans are to develop similar models for the BRICA blend components. A procedure has been developed for determining application uniformity of burley spray using an Infrared Engineering TM55 sugar monitor. The standard deviation in the sugar content is used as an indicator of application uniformity. Finally, near infrared transmission was demonstrated as a viable technique to quantify guar in cast sheet.

VI. **Objective:** Assess current methodologies, and develop and implement new technology for moisture determination in tobacco and tobacco materials.

A. **Strategy:** Evaluate the reference method (OV versus GC water) used for the calibration of on–line moisture monitors.

1. **Results:** Using the standard tobacco algorithm on the Microquad 8000 (MQ), uncased burley strip showed a difference in slope and intercept (MQ response vs

GC water or OV) relative to other strip materials (uncased bright and oriental, RCB, and RL). An algorithm was developed by K. Koller and J. Lephardt which improves the results obtained for uncased burley strip. During the development of this algorithm, GC water was used as the reference to eliminate effects due to non–water volatiles on the regressions. Effects of the GC water vs OV reference methods on the calibrations had previously been demonstrated. The new algorithm accounts for differences in sugar and ammonia content for burley relative to the other blend components. However, using the new algorithm, regression results for the other blend components do not differ significantly from those generated using the standard tobacco algorithm. Filters have been installed in a Microquad 8000 to complete the appropriate laboratory evaluations of the new algorithm.

2. **Plans:** 1) Evaluate the new Koller/Lephardt algorithm, 2) complete evaluation of the BRICA blend components and 3) install a Microquad 8000 at the Preblend cylinder in Semiworks.

3. **Contributors:** G. Hicks–White, B. Kanipe, K. Koller, J. Lephardt, D. Stagg, S. Tenhet

B. **Strategy:** Modify the GC water procedure to make it more viable as a reference method for calibration of process moisture monitors.

1. **Results:** The current GC water procedure requires a four–hour, shaking extraction of tobacco materials in methanol to achieve recoveries of ~98%. Microwave treatment of the methanol/tobacco solution decreases the extraction time from four hours (shaking) to less than 5 minutes with comparable accuracy and precision for burley and bright strip. The use of an internal standard is also being investigated. Isopropanol is the viable candidate at this time.

2. **Plans:** Complete comprehensive extraction and precision studies using the microwave treatment for all material types (strip, cut filler, ground tobacco) and blend components. The four–hour shaking procedure will be the control for the extraction study.

3. **Contributors:** G. Hicks–White, R. Jones, and D. Stagg

C. **Strategy:** Provide technical support to the Cast Leaf (CL) personnel for the Moisture Systems Microquad 8000 sensors and microprocessor.

1. **Results:** Samples were collected at the entrance and exit of the C–dryer for both the NBL (NBL–280) and CL (CLP–281) products as a follow–up to the coarse calibration and interface of the moisture monitors to the process computer completed last year. The results showed 1) the moisture monitor at the C–dryer exit can predict the %OV within ±1% absolute for the NBL product, 2) results were unsatisfactory for the monitor at the C–dryer entrance, and 3) the calibration generated using NBL can not be used for the CL product. The test results for the monitor at the C–dryer entrance are attributed to the non–equilibrium state of the

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sheet resulting from too rapid changes in the process conditions to achieve the various moisture levels. It has been recommended that manual sampling of sheet at varying moisture levels be performed by the Cast Leaf personnel during normal process runs. This procedure will better ensure that equilibrated samples are obtained. M. Parker is establishing a sampling protocol.

2. **Plans:** Complete calibration of the monitors at the C–dryer entrance as described above and continue to provide technical support as needed.

3. **Contributors:** G. Hicks–White and M. Parrish

VII. **Objective:** Develop and implement rapid technology for the on–line and off–line determination of blend composition.

A. **Strategy:** Develop and implement an analytical tool to perform blend analysis on a single cigarette rod.

1. **Results:** Four and eight component models were developed using the Bokelman sample set (DBC components) based on an FTmidIR/NIR and X–ray fluorescence analysis. A reduced set of spectral data points were selected by an analysis program written by J. Blankinship in order to significantly reduce data processing time. The prediction errors for the models varied for the individual blend components; stem showed the most favorable results for the four component model and RCB for the eight component model. The total prediction errors ranged from about 3–10% absolute. Samples of Marlboro manufactured at target weight and target weight –30 mg were analyzed using these models. The results indicated that the reduced spectral analysis may lead to reduced accuracy and precision. Further evaluation is in progress using the full spectra. Mixtures of the various blend components have been prepared to establish models for the BRICA blend. Analysis is in progress.

2. **Plans:** 1) Complete the evaluation for the Marlboro cigarettes and 2) develop models for the BRICA blend.

3. **Contributors:** C. Harward, P. Kurth, and B. Martin

4. **References:**

Harward, C. N., "Calibration Set for Prediction of Blend Composition on a Single Cigarette," memo to R. Kanipe, December 16, 1992.

VIII. **Objective:** Develop and implement monitors for ingredients added to tobacco and tobacco materials.

A. **Strategy:** Develop and implement a monitor to compare the uniformity of application of burley spray for conventional and new processing techniques.

1. **Results:** James Gear completed the statistical evaluation for the test on 10/22/92. BRICA burley strip was collected from the conventional burley spray cylinder (25 control and 100 test strips). The samples were analyzed using the Infrared

Engineering TM55 sugar monitor. The results for this test showed no differences in the spray coverage on each side of the strip. This result may be attributed to penetration of the NIR energy through the strip. The average variances in sugar content ranged from 4 to 8. If these variances are typical, then variances in the process can differ by a factor of 2 to 2.5 and still be considered reasonable. The variance of the mean % sugars from strip to strip between test groups ranged from 11 to 19.

2. **Plans:** A run has been scheduled in early March for both the conventional and DCC processes. A test protocol similar to that described above is planned for these runs. A minimum of eighty–three samples will be collected in order to detect a 20% difference in the standard deviation between spray methods using the 95% confidence interval criteria.

3. **Contributors:** M. Parrish, P. Kurth, R. Pitts, and J. Gear

4. **References:**

   Gear, J., "Variability of Burley Spray Application," memo to M .Parrish and R. Pitts, February, 12, 1993.

B. Strategy: To determine the feasibility of using near infrared transmission to quantify guar in Cast Sheet.

1. **Results:** Cast sheet samples ranging in guar content from 4 to 15 parts in 100 parts of tobacco were used to generate a calibration curve on the Katrina Protronics 112 NIT instrument. The calibration samples introduced to the spectrometer also had varying humectant and moisture levels. The calibration statistics were good considering there is no reference method on which to base the "lab" values. The results indicate the technique could differentiate sheet between sheet sample which had difference in the guar content greater than ±1.5% absolute.

2. **Plans:** No further work is planned.

3. **Contributors:** M. Parrish

4. **References:**

   Parrish, M., "Transmission NIR Analysis of Cast Sheet Varying in Guar Content," memo to R. Ferguson, December, 1992.

SUPPORT FOR LEAF MATERIALS

Summary: The phytosanitary certificate issue continued to be important for entomological support. The small lamina cycle at MZM, and the Oriental cycle at the Stockton Street facility are currently unsuitable to allow phytosanitary certification for export cut filler using tobacco conditioning.

Microbiological support for wet tobacco materials from various process sources has continued to show these to be stable for a week or more even at high OV levels.

The crop protection laboratory is now using the Yang hplc procedure to quantitate MH–30 with success. Methods for aldicarb continue to be of interest, so the laboratory is participating in a CORESTA cooperative study.

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A major effort developed around a problem which occurred at the Leaf Processing facility recently. Additional components began to occasionally appear during analysis for Kabat. A team from ARD worked closely with staff members from TQAF and from LPF to resolve this difficult analytical problem. The source of the problem was found to be components present in a carbonless paper tag placed in bags along with tobacco samples.

IX. Objective: Provide entomological technologies to Philip Morris USA for all aspects of cigarette beetle (CB) control.

A. Strategy: Use conditioning instead of methyl bromide to obtain phytosanitary certification of export cut filler.

1. **Results:** Tests to measure the efficacy of CB mortality were performed on the small–lamina conditioning cycle at MZM in McKenney, VA and on the Oriental cycle at Stockton Street. CB survivors were found using either cycle.

2. **Plans:** Recommend changing the conditioning cycles to Technical Services personnel. When the changes have been implemented, retest the conditioners for CB efficacy.

3. **Conclusions:** The conditioning cycles that were tested were not effective in killing all life stages of the CB.

4. **Contributors:** M. Tickle, T. Burruss, D. Faustini.

5. **References:**

   Burruss, T., PM Notebook No. 8896.

X. Objective: Develop appropriate methods and evaluate the microflora in tobacco and other pertinent materials.

A. Strategy: Determine microbiological activity in tobacco materials.

1. **Results:** "Wet Tobacco Materials" (WTM) from the Manufacturing Center were evaluated for susceptibility to microbial growth under permissive conditions. Even though OV values exceeded 25%, no evidence of net population increases was found over a period of at least one week.

2. **Plans:** Explore the causes of the absence of bacterial growth.

3. **Contributors:** D. Chadick, N. Thompson.

4. **References:**

   Chadick, D., PM Notebook No. 9044.

   Thompson, N., PM Notebook No. 8779.

XI. Objective: To provide methodology and measurements of crop protection agents (CPA) as needed to insure that tobacco product components and other materials meet regulatory requirements

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A. **Strategy:** Establish necessary existing and new methodology in the CPA laboratory.

1. **Results:** Four basic tobacco methods are in place (FTR Part A, organochlorines, Part B, organochlorines and organophosphorus, and herbicides). All initial modifications are now complete and documented.

   HPLC method for MH–30 has been implemented and evaluation is virtually complete.

   The evaluation of the FTR method for pendamethalin is complete.

   NCI techniques by gas chromatography–mass spectroscopy using methane reagent gas continue to show promise for confirmation of organochlorine CPA's in a sample matrix. Confirmation of the organophosphorus compounds has proved more difficult but still feasible.

   TCLP procedures are being reviewed and laboratory retraining underway. This effort is necessary to complete proper documentation and maintain functional capability in this area.

2. **Plans:** Complete performance of the TCLP methods as training exercise and review documentation in 1st quarter of 1993. Maintain basic FTR CPA capability. Complete review of HPLC MH–30 methodology by 04/01/1993. Continue the development of methodology for qualitative and quantitative confirmation of the FTR CPA's at regulatory limits by 12/31/93. Participate in a CORESTA aldicarb cooperative study in April, 1993

3. **Conclusions:** FTR methodology has been successfully integrated into the R&D environment. Confirmation of the FTR CPA's at regulatory limits continues to appear possible in samples matrices. Methodology for additional CPA's will await input from FTR.

4. **Contributors:** R. Davis, W. McCoy, G. Layman, J. Ware, N. Einolf.

B. **Strategy:** Provide documentation of methodology sufficient for laboratory operation and transfer where necessary.

1. **Results:** All applicable FTR methods have been revised and written in R&D format. They are the basis of a finished R&D CPA procedure manual. The FTR written method for pendamethalin is in hand for report. R&D HPLC method for MH–30 is in hand for use in laboratory.

2. **Plans:** Level of documentation for TCLP to be determined. Provide documentation of new methodology in R&D format within three months after commissioning. Time line is ongoing.

3. **Contributors:** R. Davis W. McCoy, W. Ryan

C. **Strategy:** Provide technical support for other PM departments on CPA issues.

1. **Results:** Provided analysis for departments outside R&D for various samples. Performed purity check of QA–TQAF standards, assisting in occasional

troubleshooting needs. Continued to maintain R&D, QA, FTR, and Leaf contacts regarding CPA issues as needed. TCLP methodology is being maintained as necessary for company needs.

2. **Plans:** Support for other PM departments is ongoing. Support for QA–TQAF and other PM departments will be ongoing.

3. **Contributors:** R. Davis, W. McCoy, G. Layman, W. Ryan, J. Ware, C. McNeilly

XII. **Objective:** Determine the source of the interferences in the quantitation of methoprene (KABAT) on stemmed leaf.

A. **Strategy:** The product and all points of process contact with tobacco were audited in an effort to match their analytical profiles with that from the interferences. Instrumentation included hplc, gc, hplc–ms and gc–ms. Daily meetings were held with appropriate QA, Stemmery and R&D personnel in tracking and reviewing the data from the R&D and QA labs.

1. **Results:** The source of the problem was identified as coming from the (carbonless paper) sample identification tags that are usually placed in the sample bags. These tags are used to note the packer location and time information for the laboratories and were found to contribute components that interfered with the analytical determinations.

2. **Plans:** Analyze samples of the vendor's carbonless paper to determine their potential for sample contamination

3. **Contributors:** B. Edwards, R. Ferguson, B. Handy, N. Jensen, D. Magin, B. Ryan, I. Smetena, M. Southwick, T. Sumpter, S–S. Yang, D. C. Watson

4. **References:**

Watson, D, "Contamination of Samples During Analysis for Methoprene," Memo to R. Dandridge, February 2, 1993

B. **Strategy:** LC/MS methods including FAB–LC/MS, FAB–LC/MS/MS, EI–LC/MS, and CI–LC/MS were applied to obtain spectral characterization of the contaminant. LC retention time and and spectra of the of the unknown were compared with those of model compounds for identification of the material.

1. **Results:** Both FAB–LC and EI–LC data not only yielded characteristic spectra for the contaminant but also showed that the contamination was due to two closely related species not a single contaminant as assumed from LC analysis alone. Tentative identification was obtained and the material was traced to sample tags which were allowed to contact the tobacco. It should be noted that LC–EI and LC–CI had not been used previously and the methods were developed to address the needs of this problem.

2. **Conclusions:** Alteration of sample handling procedures eliminated the contamination problem.

3. **Contributors:** T. Sumpter, N. Jensen

DIRECT AND INDIRECT MATERIALS EVALUATION

Summary: Support in the areas of direct and indirect materials was provided to PM USA and to International. Much of the effort remained focused on adhesives and flavors. Various possibilities were examined as potential routes to assess lot–to–lot variation of adhesives, but a definite conclusion is not possible as yet. Stick–no stick adhesive problems were investigated, but no definite differences which related to an adhesive composition problem were uncovered. The replacement stick–no stick adhesive was evaluated with respect to ingredient acceptability.

XIII. Objective: To determine the chemical compositions of materials used or proposed for use in cigarette manufacturing or found in our products.

A. Strategy: Perform appropriate infrared, X–ray, and other analyses in order to determine the chemical composition of the above materials.

1. **Results:** Numerous chemical identifications were made of materials used in the PM manufacturing facilities employing the appropriate analytical procedures. The results and the recommendations were entered into the Materials Evaluation database and reported to Quality Assurance. Materials analyzed included machine parts, conveyor belts, plastics, machine repair materials, water treatment compounds, labels, cleaners, gaskets, inks, papers, and adhesives.

   Cigarette package overwraps were examined by infrared procedures and identified as coated or uncoated polypropylene and polyethylene terephthalate. The cigarette brands tested were Salem Gold Menthol K.S., Misty Lights 120 regular and menthol, and Harley–Davidson Lights 85 S.P.

2. **Plans:** The activity of the chemical component identification by instrumental methods in support of Operations will be continued.

3. **Contributors:** M. Griff, J. Lipscomb, G. Vilcins

XIV. Objective: To provide technological support to PM USA for quality improvement by the evaluation or specification of direct and indirect materials. Provide specialized problem solving support.

A. Strategy: Identify the chemical composition of direct materials used in cigarette manufacturing employing several different analytical techniques.

1. **Results:** The analytical work to determine the chemical composition of adhesives used at PM facilities was continued. The procedures used included GC/MS for purge and trap and solvent extracted materials and infrared for the analysis of volatile and non–volatile materials. The recently received Raman spectrometer is being employed to see if this methodology could be used for adhesive evaluation without prior sample preparation treatment. The results at this time are promising.

   The program used to determine the lot–to–lot variability of the adhesives is being evaluated by PM statisticians. Head space analysis by mass spectrometric

procedures, NMR and infrared analysis of the adhesive samples also were used to determine the lot–to–lot variation. A report will be issued.

2. **Plans:** The results from the program to analyze the adhesives and their lot–to–lot variability will be issued. Other analyses will be performed as necessary.

3. **Contributors:** K. Dudzinski, N. Einolf, M. Griff, C. Keene, J. Lipscomb, K. Sanders, G. Vilcins.

XV. **Objective:** Develop analytical and sensory specifications for incoming flavors used by PM USA. Transfer specifications and methodology to the Flavor Center and Technical Services.

A. **Strategy:** Work with Technical Services, Purchasing, QA, and other R&D staff as required to transfer specifications and methods as vendor agreements are obtained. Discuss specs and methods with vendors to reach agreements on same.

1. **Results:** Negotiations continued with the vendors. With one vendor a tentative agreement has been reached for 13 out of 26 materials. For the remainder of the materials from this and the other vendors, negotiations are continuing. The specification group is working with the Flavor Center to adjust methodology where necessary and assist in the implementation as needed.

   Biweekly meetings are attended by the specifications group at the Flavor Center with personnel from technical services, purchasing, regulatory and the Flavor Center. These meetings are intended to resolve any issues that may evolve and to help better organize the remaining specification process.

2. **Plans:** Continue to support Purchasing in obtaining agreements with vendors. Develop additional flavor specs as required.

3. **Contributors:** B. Baronian, N. Einolf, K. Sanders, G. Vilcins

XVI. **Objective:** To characterize and identify materials used in the manufacture and packaging of products.

A. **Strategy:** Use light microscopy, scanning electron microscopy, and energy dispersive spectroscopy to analyze the samples.

1. **Results:** Two board samples from cartons of Marlboro hard and soft pack were examined to determine the cause of excessive adhesion of the stick–no–stick adhesive. Tearing of the carton top occurred when the box was opened for tax stamp application, making it unacceptable for resale. A control Marlboro Red FTB board sample was also examined. The only difference found among the three samples was the difference in water absorption on the inside surface of the top large flap. Compared to the control, both test samples absorbed water into the surrounding board matrix faster. The drop of water on the control box remained on the surface until it evaporated into the air.

2. **Contributors:** V. Baliga

3. **References:**

Baliga, V., "Morphological and Elemental Characterization of Board Samples," Memo to B. Faucet, November 16, 1992.

XVII. Objective: Utilize microbiology to evaluate direct materials.

A. Strategy: Determine microbiological activity in other direct materials.

1. **Results:** At the request of Flavor Technology, samples of a flavor formulation in storage were examined for evidence of microbiological activity. No growth of bacteria, yeast or mold was detected after incubation under permissive conditions. Results were communicated to the requester.

   At the request of Technical Services, samples of water–based adhesive materials (tow anchor, carton end, side seam) were subjected to tests of the efficacy of the preservatives that they contain. This work is in progress.

2. **Plans:** Continue to respond to requests.

3. **Contributors:** D. Chadick, N. Thompson.

4. **References:**

   Chadick, D., PM Notebook No. 9044.

   Thompson, N., PM Notebook No. 8779.

   Chadick, D, "Evaluation of Microorganisms in Flavor #00–220," Memo to S. Ruziak, February 3, 1993.

SUPPORT TO FINISHED PRODUCT QUALITY

Summary: A significant effort is ongoing to evaluate unauthorized product in the international marketplace. This is a worldwide issue, but much of the recent focus has been on Asia. A wide range of analytical investigations are in progress on an ongoing basis in support of this program. Increased support for this program has been requested by I.O.S. and this increase will commence immediately.

XVIII. Objective: To characterize cigarette products that were sold as US export. The project is a joint effort between IOS, Richmond R&D, FTR–R&D, Lausanne, and the sales force with the objective of identifying and eliminating the source of unauthorized operations.

A. Strategy: Analyze unauthorized products, authorized licensees, affiliates, competitors' products, and raw materials from known vendors. Coordinate analyses obtained from the same. Infrared microscopy, scanning electron microscopy, energy dispersive X–ray spectroscopy and scanning laser microscopy were used for these investigations.

1. **Results:** Richmond R&D was established this quarter as the principle analytical site for the Fausto project. To date, 32 unauthorized samples have been fully analyzed. Tear tape information, tipping compositions, adhesives, and monograms appear to be region specific. Three of the most recently received samples have

required rapid turnaround to aid investigations in Southeast Asia and Europe. For one of these sample (F2–031), the overwrap, adhesives, tipping ink composition, and physical characteristics were analyzed and found to be sufficient to identify the producer. For the two others (F3–001 and F3–002), the monograms adhesives, adhesive applications, tear tape composition and outline, and physical characteristics were similar to another source of unauthorized products picked up in Southeast Asia (Cambodia, Laos, Taiwan, Indonesia, Philippines). This suggests that the same producer was responsible for the above cigarettes. Tear tape cut design from 24 competitors' cigarette packages were evaluated, compiled, and compared to unauthorized products. Eight of the competitors' samples were from Indonesia and were also analyzed for adhesives, flavors, sugars, plasticizers, and physical characteristics. Samples from 3 affiliates have been partially analyzed and tipping papers from various vendors have also been analyzed.

2. **Plans:** Continue to examine unauthorized products and known vendors' products as they become available. New information will be compared to and added to the existing data base.

3. **Contributors:** V. Baliga, D. Miser, M. Griff

4. **References:**

Miser, D., "Unauthorized Product Sample F2–031," Memo to G. Morgan, January 25, 1993.

Miser, D., "Summary of Analyses of Samples F3–001 and F3–002," Memo to G. Morgan, February 6, 1993.

XIX. Objective: To determine if foreign materials are present and to characterize morphology and elemental content of the same in customer complaint samples.

A. Strategy: Use light microscopy, scanning electron microscopy, and energy dispersive X–ray spectroscopy to analyze the samples.

1. **Results:** Six customer complaint samples were examined this quarter. Three samples involved foreign materials found in the cigarette, two contained a brownish–red stain and one sample was a cigarette butt suspected to be from a foreign brand.

- Sample #92058 contained a foreign material that appeared to be a piece of plastic of unknown origin.
- Sample 9259 was a cigarette with a brown stain on the filter. The stain was not identified, however, it was shown not to contain blood.
- Sample #92060 contained two foreign fibers that appeared to be "plastic" fibers from a woven fabric of unknown origin.
- Sample #93002, a cigarette butt found in a gum and salt mixture from Kraft, was determined not to have been a Philip Morris USA brand nor was it one of 320 other American brands listed in the December 1992 CI report.

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- Sample #93063 contained three cigarettes with a brownish–red stain on the tipping paper. The stain produced a positive reaction to the presumptive test for blood.
- The black rubbery material found in a Marlboro Light cigarette (sample # 93001) was identified.

2. **Contributors:** L. Thompson, V. Baliga, D. Miser, M. Griff

3. **References:**

Baliga, V., "Customer Complaint #92058," Memo to S. S. Yang, December 7, 1992

Baliga, V., "Customer Complaint #92059," Memo to S. S. Yang, December 2, 1992.

Baliga, V., "Customer Complaint #92060," Memo to S. S. Yang, December 14, 1992.

Miser, D. "Customer Complaint #93002," Memo to D. Curle, February 10, 1993.

Baliga, V., "Customer Complaint #92063," Memo to S. S. Yang, January 8, 1993.

Thompson, L. "Customer Complaint #93001," Memo to S. S. Yang, January 20, 1993.

Griff, Mike. Notebook No. 9233, p.26.

B. **Strategy:** Support Quality Assurance personnel in the area of insect related customer complaints.

1. **Results:** Nineteen potential insect related customer complaints were examined. Eight were found to be related to cockroaches, 6 were due to CBs and in the remainder of the complaints, no insect infestations could be found.

2. **Plans:** Continue to examine potential insect related customer complaints at the request of Product Audit personnel.

3. **Conclusions:** Of the insect related customer complaints, 32% were found to be related to CBs.

4. **Contributors:** D. Coar

5. **References:**

Coar, D., PM Notebook No. 9227.

PROGRAM NAME : Summary of Other Programs
WRITTEN BY : P. N. Gauvin
PERIOD COVERED : First Quarter, 1993

Coordinator Summary: During the First Quarter 1993, the Computer Applications Group has completed several activities. A second Robotics test station was installed in the CTSD Physical Testing Lab and PCs and UNIX work stations are being installed in the TPM Smoking Lab to replace obsolete data acquisition systems. An analysis of consumer data to discover general relationships between brand switching behavior versus smoker demographics and product attributes was completed, and a report was issued. Neural network modeling is in progress to predict brand switching behavior.

In support of the Cigarette Paper Consolidation Program, a set of Neural Network models was developed to predict cigarette performance as a function of the paper parameters. Through the use of expert systems, the tracking of the BL dryer belt is being improved, which should result in increased production at the BL Plant.

The ISO 25 Accreditation Team is continuing the development of a quality manual for the combined CTSD/Product Audit Division. A project team was chartered and has completed the documentation for the determination of cigarette paper porosity.

In the predictive maintenance area, sensor locations, cable routing, and installation protocols were finalized for permanently mounting accelerometers on X–500 and X–2 packers in the Manufacturing Center. The preparations for installation have involved the coordinated efforts of York Engineering, R&D, and the MC.

Several new analytical capabilities have been acquired or developed during this quarter in the Analytical Research Division which enhance ARD's ability to address Analytical issues. These include the installation of a Nicolet Raman 910 spectrometer to facilitate identification of the chemical composition of adhesives and characterization of materials used in papers, filters, packaging, and flavors.

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PROGRAM NAME : CTSD ISO 25 Accreditation
WRITTEN BY : J. M. Garman
PERIOD COVERED : First Quarter, 1993

I. Objective: To pursue and obtain ISO Guide 25 accreditation for the consolidated CTSD/Product Audit laboratory.

A. Strategy and Results: The ISO 25 team continues to develop a quality manual for the combined CTSD/Product Audit Division. Completion of the quality manual is targeted for March 31, 1993. A project team was chartered and has completed the development of documentation for the determination of cigarette paper porosity. Those groups which service the new product testing laboratory (CAD, Building Administration, and QA Standards Lab) have been formally requested to develop documentation covering their functions and services relevant to supporting our laboratories.

1. **Plans:** Continue development of a quality manual for the consolidated CTSD/Product Audit testing operation. Coordinate the development of appropriate documentation as outlined in ISO Guide 25.

2. **Contributors:** Q.A. Standards Laboratory, International Operations Support

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PROGRAM NAME : Predictive Maintenance
WRITTEN BY : K. H. Shafer
PERIOD COVERED : First Quarter, 1993

I. Objective: Develop vibration analysis as a tool for predicting and diagnosing machine health and as a design aid for improving machine performance.

A. Strategy: Establish procedures for obtaining vibration signal histories of packers at the Manufacturing Center. Develop analysis procedures using advanced signal processing techniques.

1. **Status:** The signal processing packages DADisp and Mathcad have been installed and system integration begun in a PC environment. A set of vibration data on the packer subassembly was acquired using the TEAC tape recorder. The data were transferred to the Mathcad environment without error, demonstrating that the interface software is functional. Sensor locations, cable routing, and installation protocols were finalized for permanently mounting the accelerometers on X–500 and X–2 packers in the MC. The preparations for the installation have involved the coordinated efforts of York Engineering, R&D, and MC. Installation will be more difficult in Bay–4 than in Bay–1 due to the lack of access to measurement points which are covered by the X–2 casting. The cover of each packer will be modified at York Engineering.

2. **Plans:** The accelerometer installation is proceeding in Bay–1 and Bay–4. During this installation, data will be acquired manually and analyzed using the SKF and signal processing software.

3. **Contributors:** S. N. Ganeriwala, H. M. Dante, A. T. Hill.

PROGRAM NAME : Research on Analytical Methods
WRITTEN BY : N. Jensen And S. Yang
PERIOD COVERED : First Quarter, 1993

I. Objective: To install a Nicolet Raman 910 Spectrometer which will be used by the Materials Specification and Evaluation group for structural or compositional characterization of material used at PM facilities.

A. Strategy: Raman spectroscopy will be used to facilitate identification of the chemical composition of adhesives and characterization of materials such as materials used in papers, filters, packaging, plasticizers and flavors.

1. **Results:** Installation has been completed and spectra have been obtained with the new instrument.

2. **Plans:** Use of this instrumentation is in progress.

3. **Contributors**: G. Vilcins

II. Objective: To install a Leco Corporation FP–428 nitrogen analyzer to measure total nitrogen.

A. Strategy: This analyzer measures nitrogen by converting the chemically bound nitrogen to nitrogen oxides by high temperature combustion of the sample and subsequent catalytic conversion of the evolved nitrogen oxides to reduced N_2 which is then measured by a thermal conductivity cell.

1. **Results:** Total nitrogen data from both the FP–428 and the current nitrogen analyzed the FP–228 were statistically compared to determine how the new instrument compared to the previous instrument. Statistical analysis of the data indicated that comparable results were obtained with the FP–428 yielding less variability.

2. **Plans:** Use of this instrument is in progress.

3. **Contributors:** W. Ryan

III. Objective: To install a Varian Saturn II GC/MS.

A. Strategy: This system which may be operated in either electron impact and chemical ionization modes will be employed for both conventional gas chromatography and purge–and–trap mass spectral analyses.

1. **Results:** The Varian Saturn II system is presently being used for the analyses of volatile organic compounds in environmental samples.

2. **Plans:** Use of this instrument is in progress.

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3. **Contributors:** W. Ryan

IV. Objective: To develop HPLC–chemical ionization mass spectrometry (HPLC–CI/MS) and HPLC–electron impact mass spectrometry (HPLC–EI/MS) which are two new high performance liquid chromatography methods that can provide information which is complimentary to the previously instituted HPLC–fast atom bombardment mass spectrometry (HPLC–FAB/MS) analysis.

A. Strategy: These new ionization methods are best suited for the analysis of more volatile, lower molecular weight components. No FAB matrix is required; thus, the reduction in background ions facilitates observation of smaller molecules.

The use of HPLC–CI/MS takes advantage of the presence of the mobile phase to generate a "reagent gas" by electron bombardment within the ion source of the MS. This reagent gas is typically a protonated component of the mobile phase itself, which in turn is capable of protonating analyte molecules. The resulting mass spectrum typically contains primarily protonated molecular ions of the analyte (providing molecular weight information) with little background below 100 amu. Modification of the "reagent gas" can be accomplished by the post–HPLC column addition of other compounds which vary the acidity/basicity.

HPLC–EI/MS is operationally similar to HPLC–CI/MS. However, in HPLC–EI/MS, the analyte molecules are ionized using a 70 eV beam of electrons. Fragmentation is extensive by this method thus providing structural information of the components in the mixture. Both methods can accommodate normal or reversed phase HPLC columns using capillary, microbore, narrowbore or analytical columns.

1. **Results:** These methods have been applied to the analysis of a containment interfering with Kabat analysis and analyses of offset printing materials.

2. **Plans:** These methods will be applied as needed in analytical investigations.

3. **Contributors:** T. Sumpter

V. Objective: Post Column Reaction System

Results: An HPLC post–column reaction system was installed and its function was tested. This system consists of two sets of reagent pump with reaction coil and the whole unit is placed between the outlet of an HPLC column and the inlet of a detector. The main function of this system is to derivatize the target compounds in the column eluant for the subsequent detection. Several aliphatic amines were used as test probes and were successfully derivatized with a fluorescence reagent.

Plans: Method developments and applications using this system are in progress.

Contributors: S. S. Yang and I. Smetena

VI. Objective: Method Development for Amino Acids in Tobacco by HPLC–Fluorescence.

Results: An HPLC/fluorescence procedure for the determination of several amino acids in tobacco has been developed. Sample preparation consists of a single extraction of tobacco using 50% ethanol with the aid of sonication for 10

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minutes, precolumn derivatization by mixing tobacco extract with reagents in an HPLC autosampler vial and waiting for 20 minutes at ambient temperature. The HPLC separation is performed on a Novapak C–18 column at a reversed–phase, gradient elution mode with a mixture of methanol and a phosphate buffer as the mobile phase. Due to the use of a fluorescence detector, amino acids are selectively and sensitively detected which provides an easy way for quantitation. The whole analysis can be completed within an hour and the sample throughput could be more than 50 samples per person per day.

Plans: The application of this procedure on the other tobacco related materials, e.g., cooked flavor, will be evaluated.

Contributors: S. S. Yang and I. Smetena

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PROGRAM NAME : Computer Applications Division
WRITTEN BY : M. Allred, J. Blankinship, B. Kane, J. Palesis
PERIOD COVERED : First Quarter, 1993

I. Objective: Migrate the CTSD Instrument Workstations (IW) to the new Cigarette Quality System (CQS).

A. Strategy: Modify programs on the IWs to handle new barcodes, sample/test identification, and database load procedures.

1. **Results:** Selected instruments in the TPM Smoking, Nicotine and Water, Menthol, Material Evaluations and Physical Testing labs have been modified for the new CQS. Samples have been run on these instruments and results shipped to the new database.

2. **Plans:** Continue migrating instruments to CQS (March, 1993). Provide support as needed.

3. **Contributors:** Ronnie Buckner, Brant Daughtry, Randy Greene, Nick Latif

II. Objective: Automate data transfer between MEL instruments (Firmness, CV/OV, and Sieves) and the CTSD database. Also provide for direct sample handling for Semiworks and NPP.

A. Strategy: Revise the MEL Instrument Workstations for the new Cigarette Quality System (CQS) and connect them to the new system.

1. **Results:** Modifications are in progress. The Firmness instrument is operational on the new system.

2. **Plans:** Install CV/OV and Sieves on CQS by March, 1993.

3. **Contributors:** Ronnie Buckner, Brant Daughtry, Nick Latif

III. Objective: Install a Second Robotics Test Station in the CTSD Physical Testing Lab.

A. Strategy: Configure the new system like the current system and test.

1. **Results:** The new system is operational.

2. **Plans:** Migrate this instrument to CQS by March, 1993.

3. **Contributors:** Ronnie Buckner

IV. Objective: Modernize the TPM Smoking lab.

A. Strategy: Use PCs and UNIX workstations to replace obsolete data acquisition systems.

1. **Results:** Robotics weighing is operational for the old CTSD lab system. Manual weighing with a UNIX workstation is operational. The automated collection of puff counts from manual smokers and robotics smokers is operational. Four core programs have been converted to work with the new Cigarette Quality System.

2. **Plans:** Migrate the rest of the TPM Smoking Lab programs to CQS by April, 1993. Complete a PC version of the manual weighing station.

3. **Contributors:** Randy Greene

V. Objective: Analysis and Modeling of Brand Switching Behavior

A. **Strategy:** (1) Analyze consumer data to discover general relationships between brand switching behavior vs. smoker demographics and product attributes, (2) Develop neural network models which can be used to predict brand switching behavior as a function of smoker demographics and product attributes, and (3) Explore the use of bi–linear regression techniques such as Principal Component Regression (PCR) and Partial Least Squares (PLS) to help predict and explain brand switching behavior.

1. **Results:** A statistical analysis of brand switching data from the 1990–91 Continuous Tracking Study was completed to determine the impact of smoker demographics and product attributes on the propensity to switch. The switching propensity is a measure of the likelihood or probability that a smoker will switch brands during some time period. Eight demographic variables (gender, age, race, income, education, marital status, Nielsen county, and region) and six product attributes (cigarette length, menthol, packing type, tipping color, price, and tar level) were considered. The statistical methodology was primarily descriptive and inferential in nature. Two–way frequency tables were formed to classify brand switching against each demographic and product category – both overall and stratified on each other categorical variable. The frequency tables were visually examined and statistically tested for independence and linear trends to assess the first– and higher–order effects of the categorical variables on the switching propensity. The use of log–linear categorical modeling was also investigated using BMDP Program 4F (Two–Way and Multiway Frequency Tables) in an attempt to better understand the higher–order effects. This modeling effort was only partially successful due to time constraints and BMDP memory limitations on the number of factors which can be modeled simultaneously. The research identified key relationships between switching propensity and several of the demographic and product factors, including: gender, age, race, income, marital status, Nielsen county, cigarette length, and packing type. Also, a general phenomenon called the "Principle of Cultural Switching" is observed which appears to influence much of the brand switching behavior. Internal report 93–003, *Impact of Smoker Demographics and Product Attributes on Switching Propensity*, was prepared to document the results of this research.

   Neural network modeling is also being performed to complement the statistical analysis. A set of neural network models was developed to predict (1) the probability or likelihood of switching, (2) the post–switch brand attributes, and (3)

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the post–switch brand family – as a function of the pre–switch brand attributes and pre–switch brand family. Separate neural networks were developed for each post–switch brand attribute (cigarette length, menthol, packing type, tipping color, price, and tar level). These neural network models are being incorporated into a brand switching decision support system for potential use in consumer research, direct marketing, brand management, and product design.

In support of this neural network modeling, the N–fold cross–validation procedure was enhanced to improve the determination of how long training should continue so as to optimize the generalization performance of the model.

2. **Plans:** Develop a set of neural network models to predict brand switching behavior as a function of smoker demographics alone (March, 1993), as well as smoker demographics and product attributes (May, 1993). Statistically analyze data from the 1991–92 Tracking Study to determine the impact of smoker demographics and product attributes on the kind of brand switch that is made (July, 1993) – e.g., how does a smoker's decision to switch to a different tar level or price category depend on the smoker's demographics and pre–switch brand attributes? Statistically analyze data from the 1991–92 Tracking Study to determine the impact of smoker demographics and product attributes on alternate brand purchases (September, 1993).

3. **Contributors:** J. Blankinship

VI. Objective: Channel Selection For Multicomponent Calibration

A. **Strategy:** In support of Process Monitoring for Primary Technology, develop a software algorithm for wavelength selection in multicomponent near–infrared (NIR) calibration.

1. **Results:** A software algorithm was developed to select a set of spectral wavelengths (channels) and other analytical measurements which are most correlated to the concentration of a blend component with minimal interference from other wavelengths. The algorithm was based on an article in the Journal of Chemometrics titled "Wavelength Selection in Multicomponent Near–Infrared Calibration." The algorithm was applied to NIR and X–ray fluorescence data from ARD, and greatly reduced the number of independent variables prior to the use of Partial Least Squares (PLS) Regression. The resulting set of channels decreased the PLS processing time from several hours to a few minutes, and improved the predictive accuracy by a factor of two.

2. **Plans:** Develop a neural network calibration model to predict the concentration of a blend component as a function of spectral and other analytical measurements (March, 1993). Compare its performance with that of PLS Regression.

3. **Contributors:** J. Blankinship

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VII. Objective: Cigarette Performance Model For the Paper Consolidation Study

A. Strategy: Develop and deliver for user operation a neural network model for prediction of cigarette performance as a function of paper parameters. This model was used to support the Paper Consolidation Study.

1. **Results:** A set of neural network models was developed and delivered for user operation. Separate models were developed for TPM, tar, puff count, and static burn time. The explanatory variables for each model were the basis weight, chalk content, porosity, and citrate level of the cigarette paper as well as the cigarette class (ultra low, flavor low, or full flavor). For each dependent variable, a single neural network model was developed based on training examples across all three cigarette classes, rather than separate models for ultra low, flavor low, and full flavor. The models have been used extensively to determine cigarette paper parameters for future test cigarettes with prescribed delivery and puff count targets.

2. **Plans:** No additional work is planned.

3. **Contributors:** J. Blankinship

VIII. Objective: Provide planning, technical support and integration of the desktop computing devices in use within the Research Center

A. Strategy: Develop and implement the consistent and effective desktop support methodologies needed to accommodate the R&D desktop computing needs.

1. **Results:** A maintenance contract has been finalized with Microsoft that will allow all R&D desktop systems, 386 or better PCs and all Macintosh systems, to run the most recent version of MS–DOS, MS–WINDOWS, MS–WORD, MS–EXCEL and MS–POWER POINT. With the goal of all R&D desktop systems running the same version of system and productivity software, this maintenance contract will save the company significant costs as well as eliminate a lot of administrative activities.

   The CTSD/QA merger project has incorporated modernization along with the actual merger. A significant portion of this modernization has been to replace terminals with desktop computers. During the project 40 new PC systems were purchased and installed in support of the project. All these PC's are network connected and are loaded with the latest versions of the CAD's recommended productivity software.

2. **Plans:** Complete all desktop activities associated with the CTSD/QA merger by March 1, 1993.

   Develop a plan and begin implementation of software upgrades for all R&D computer systems covered under the Microsoft maintenance contract by March 1, 1993.

3. **Contributors:** CAD Distributed Systems Group

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IX. **Objective:** Provide planning and technical support for the R&D network infrastructure and those devices requiring network based resources.

A. **Strategy:** Maintain cost effective and efficient support methods to accommodate a growing R&D network environment.

1. **Results:** The Scientific Affairs division was relocated from the Operations Center to E–Building. Although the number of people moved was not a large undertaking, they had very specific network connectivity needs. Scientific Affairs does not require R&D computer systems access but does require high speed network connection with PMUSA in New York. To accomplish this, special wiring and additional network equipment had to be purchased and installed to provide the needed connectivity in the R&D complex. In addition to the wiring, all the Scientific Affair computer systems were converted from token–ring to ethernet based communications.

   The CTSD/QA merger has required a significant amount of network support. New network equipment was purchased and installed to increase the connectivity needed to support the 50 to 60 new desktop systems that were added to the R&D network. In addition the method of distributing the network throughout the laboratories was reworked to increase connectivity and to eliminate the broadband as a point of failure between the data collection systems and the server systems.

2. **Plans:** Complete the network related activities needed during the final stages of the CTSD/QA merger by March 1 1993.

   Investigate the feasibility of installing a CISCO router between the R&D and IS ethernets to provide the required security between the networks while allowing appropriate and approved high speed data communications.

3. **Contributors:** CAD Distributed Systems Group

X. **Objective:** BL Dryer Belt Tracking

A. **Strategy:** Use expert systems, fuzzy logic, and machine learning to improve tracking of the BL Dryer Belt and thus substantially increase production. Improved tracking will increase production by: (1) minimizing downtime, (2) minimizing wear and tear of critical process components, and (3) making it possible to expand the width of the belt which carries the slurry through the dryer.

1. **Results:** (1) Permanent installation on line 3 — The Allen–Bradley PLC–5 has been selected as the hardware platform for the permanent installation of the BL Plant belt tracking expert system. The PLC–5 provides a co–processor which can run the expert system C code with only some minor modifications. The PLC–5 will initially be used for steady–state belt tracking on line 3. All the necessary signals for steady–state belt control have been made available to the PLC–5 and the interface between the PLC–5 and the expert system is nearing completion. A man–machine interface is also being developed. Release of the expert system on line 3 is expected to take place before the end of March, 1993.

(2) Automatic belt startup feature — The BL belt tracking expert system has been expanded to include a "hard" startup capability (i.e., to restart the belt automatically after the belt has tracked off). The interface between line 2 and the PC running the expert system on that line has been enhanced to include the belt tracking signals necessary for this new task. After several interviews with human belt tracking experts at the BL Plant, a "hard" startup control strategy has been developed and implemented as a function in the existing expert system. On–line testing demonstrated that an automatic "hard" startup is quite feasible and that the control strategy implemented for this task is practical. Several deficiencies in the initial implementation of this new feature were also identified and are presently being corrected.

2. **Plans:** Short term plans include the following:

   (1) Complete permanent installation of expert system on line 3 by March 31, 1993;

   (2) Continue developing the "hard" startup feature on line 2.

3. **Contributors:** J. Palesis